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ILLUMINATION SYSTEMS AND METHODS OF USE

FIELD OF THE INVENTION

The invention is directed generally to portable illumination systems, and more particularly to a hands-free/body-mounted light emitting diode (“LED”) as a light source.

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BACKGROUND OF THE INVENTION

Conventional portable illumination systems, such as flashlights, include an incandescent light bulb and conventional drycell batteries enclosed in a housing typically constructed of a body section and a head section. Though portable, illumination systems of this type are often bulky and cumbersome, and thus often are not carried on the person. This presents a problem when the need for illumination arises unexpectedly, such as during a power failure at night, and no portable illumination system is readily available. The problem is exacerbated when, for instance, the person does not have a hand available to search for, aim and operate a conventional flashlight.

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There have been some variations on portable, hands-free illumination systems. Underground coal miners have long mounted large conventional incandescent lights with large, heavy battery packs to the front of hard hats, allowing them to work with both hands while the light on the hat illuminated the area in front of them. U.S. Patent No. 3,032,647 to Wansky provides an example of a hat-mounted light. U.S. Patent No. 4,616,297 to Liu also provides an example of a hands-free flashlight, which mounts conventional incandescent light bulbs and conventional drycell batteries to a bulky frame to be worn like spectacles.

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5 U.S. Patent Nos. 5,217,294 to Liston and 5,412,545 to Rising describe hands-free operation of a conventional flashlight by strapping the flashlight to the user's head.

While any of these devices, if worn by a user, might function as a hands-free illumination device, such devices are even more bulky and cumbersome than conventional flashlights. Moreover, such devices are not suitable for use in conjunction with other
10 headgear.

Conventional hands-free portable illumination systems are bulky primarily because they use incandescent light bulbs, which suffer from poor efficiency in converting electrical power into radiated visible light. Most of the electrical energy incandescent light bulbs consume is wasted in the form of heat energy, while less than 7% of the energy they consume
15 is typically radiated as visible light. This has severe negative consequences for portable illuminator applications, such as hands-free illumination devices, where the amount of power available for lighting systems is limited. In these applications, electrical power is usually provided by batteries which are periodically replaced, as in the case of a flashlight. Such a mechanism for providing electrical power is inherently bulky, heavy, and/or expensive due at
20 least in part to poor power-conversion efficiency in generating visible light.

As already noted, incandescent lamps generate large amounts of heat for an equivalent amount of generated light as compared to other sources. This results in very high bulb-wall temperatures typically in excess of 250 degrees Celsius and large heat accumulations which must be dissipated properly by radiation, convection, or conduction to
25 prevent damage or destruction to the illuminator support members, enclosure, optics or to other nearby components. Providing room for the necessary heat dissipation requires additional bulkiness. This high heat signature of common incandescent light sources in

5 illuminators is particularly problematic for hands-free light sources, where the light source is in close proximity to the user's body, for instance, the user's head.

Incandescent light bulbs, or lamps, are also disadvantageous because they are fragile and have a short life. Even in stable environments incandescent lamps must be replaced frequently, sometimes at great inconvenience, hazard, and/or expense. In addition to their
10 short life, incandescent lamps are susceptible to damage from mechanical shock and/or vibration. Such occurrences can damage the delicate filaments from which incandescent light emissions originate, or can damage the surrounding glass casing, which can result in air entering the casing and quick burning out of the filament. Incandescent lamps can also be easily damaged by exposure to liquid moisture, due to the thermo-mechanical stress
15 associated with contact between the hot glass bulb wall and cooler fluids. Thus, incorporating an incandescent lamp into a hands-free illumination device requires substantial or extreme measures to protect the light bulb from shock, vibration, moisture and other hazards while still allowing for removal of the bulb or light fixture when it burns out, is permanently damaged or otherwise loses power.

20 Incandescent light bulbs or lamps also exhibit certain electrical characteristics which make them inherently difficult to incorporate in small, lightweight applications, like hands-free illumination devices. For instance, when an incandescent light source is first energized by a voltage source, there is an initial surge of current which flows into the filament. This inrush current, which is typically 12 to 20 times the normal operating current, limits the
25 lifetime of the lamp thus further amplifying the need for an illuminator structure which allows for frequent replacement. Inrush current also necessitates unusual consideration when designing supporting electrical circuits which contain them. Fuses, relays, mechanical or

5 electronic switches, wire harnesses, and connectors electrically connected to such lamps must be capable of repeatedly carrying this extreme transient.

In addition, the voltage-current (V-I) characteristic of incandescent lamps is notoriously non-linear, as are each of the relationships between light output and voltage, current, or power. The luminous intensity, color temperature, and service life of incandescent lamps varies exponentially as a function of applied current or voltage. This sensitivity to power source variation makes electronic control of incandescent lamps a particularly difficult problem. They are further susceptible to significant reliability and field service life degradation when subjected continuously to DC electrical power, pulse-width modulated DC power, simple on/off switching of any sort, or any over-voltage conditions, however minor.

15 Incandescent lamps also possess significant inductance which, when combined with their relatively high current load, complicates electronic switching and control greatly due to inductive resonant voltage transients.

SUMMARY OF THE INVENTION

A light emitting diode ("LED") is provided as a light source for use in hands-free illumination devices. In one embodiment, a hands-free illuminator using LED technology is provided in the form of an aircraft headset, such as a pilot's headset. In another embodiment, a kit is provided to convert existing headgear, such as an aircraft headset, into a hands-free illumination device.

Unlike conventional incandescent light bulbs/lamps, LEDs are highly efficient, in that most of the power consumed by an LED is converted into visible light. The efficiency of LEDs allows them to be incorporated into compact, streamlined designs with smaller and lighter batteries or other power sources. Further, LEDs are highly shock resistant and therefore provide significant advantages over incandescent and fluorescent bulbs, rendering LEDs ideal for critical applications, such as pilot-mounted aircraft cockpit illumination. LEDs possess operating lifetimes from 200,000 hours to 1,000,000 hours, as compared to the typical 1,000 to 2,000 hours for incandescent lamps. Finally, LEDs avoid the transience and inductance problems associated with incandescent lamps, allowing LEDs to be incorporated into various structures using simple circuitry.

Until recently, LEDs did not produce enough light to illuminate another surface. Thus, most LEDs were used as display devices, for example, on/off indicators, etc. These uses still dominate the LED market, but recent advances in LED materials, design and manufacturing have resulted in significant increases in LED luminous efficacy and, in their most recent commercial forms, exhibit a higher luminous efficacy than incandescent lights. Thus, the latest LEDs can provide as much illumination as conventional incandescent lamps.

5 In one embodiment of the invention, an apparatus is provided including one or more high-intensity LEDs attached to headgear, such as an aircraft headset. Other embodiments could provide one or more high-intensity LEDs along with spectacles, hat, helmet, headband or the like. In the headset embodiment, the LEDs may receive power from one or more batteries integrated with the headset, and/or from a power source external to the headset. In 10 the case of an external power source, electrical power may be communicated through the existing headset power and/or communication cables, or through other means, including dedicated wires. The LEDs may be controlled by a switch or switches (e.g., integrated with the headset), such that a user (e.g., a pilot) can cause the LEDs to illuminate by actuating the switch. The LEDs are preferably oriented in or on the headset to direct the LEDs' luminance 15 in the direction the headset wearer is looking, to illuminate the area of interest (e.g., cockpit instruments, dials or gauges). LEDs of various colors may be used, to produce, for instance, white, blue or red light. It is known that red light is optimal under some conditions, such as for example nighttime vision.

 In one version of this embodiment, the LEDs and/or switches are incorporated into a 20 conventional pilot headset. In another version of this embodiment, the LEDs and/or switches are part of a separate device that can be attached to a conventional pilot headset. In the version utilizing a separate device, the power source, for instance a battery, is preferably, but not necessarily, incorporated into the separate device.

 In another embodiment of the invention, a kit is provided to retrofit existing headgear, 25 such as pilot headsets and the like, with LEDs. Such a kit may include one or more of any or all of the following: a high-intensity LED; electrical wire or other conductor; grommet; a wire shield; a switch; a rubber boot; a battery holder; a battery; a power pack; a template;

5 tape; a drill bit; a pin clamp; a fuse; a fuse holder; a zener diode; screws and/or other types of
fasteners; epoxy; a clip and instructions. Any or all of the electrical components and/or
electronics may be provided as part of a pre-assembled or partially assembled circuit. A
method of using/installing the kit is also provided.

10 In yet another embodiment a system and method is provided to combine what is
essentially a compact, lightweight LED flashlight with existing headgear, such as headsets,
spectacles, hats, helmets, and headbands, to illuminate the headgear wearer's area of interest.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation view of a headset for a pilot incorporating LEDs and switches according to one embodiment of the invention.

FIG. 2 is a left elevation view of a headset incorporating LEDs and toggle switches
10 according to one embodiment of the invention, with a user wearing the headset.

FIG. 3 is a right elevation view of a headset incorporating LEDs according to one embodiment of the invention, with a user wearing the headset.

FIG. 4 is a left elevation view of a headset incorporating LEDs and a 3-way switch according to one embodiment of the invention, with a user wearing the headset.

15 FIG. 5 is an isometric view of a battery according to one embodiment of the invention.

FIG. 6 is a left elevation view of a headset incorporating LEDs and a battery access door according to one embodiment of the invention, with a user wearing the headset.

FIG. 7 is diagram of a circuit useful in one embodiment of the invention.

20 FIG. 8 is diagram of a circuit useful in another embodiment of the invention.

FIG. 9 is an illustration of retrofitting a headset to incorporate LEDs using a kit according to one embodiment of the invention.

FIG. 10 is an illustration of an add-on device for adding LED illumination to existing headgear.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no
10 limitation of the scope of the invention is thereby intended, and alterations and modifications in the illustrated device, and further applications of the principles of the invention as illustrated therein, are herein contemplated as would normally occur to one skilled in the art to which the invention relates.

The present invention is directed to hands-free illumination devices using LEDs, and
15 is described below primarily in the context of illumination devices used in conjunction with headgear, in particular aircraft headsets. However, other embodiments covered by the invention simply substitute for aircraft headsets any other body-mounted object, including headgear such as: spectacle-like frames, including safety glasses; hats, including hardhats; helmets; and headbands. Hereafter the invention is described with respect to a preferred
20 embodiment, aircraft headsets.

Referring now to FIG. 1, an embodiment of an aircraft headset 20 is shown. Headset 20 includes a first set of LEDs 10, a second set of LEDs 11 and switches 50. The illustrated embodiment of headset 20 includes a headband 22, spaced apart ear cups 24, 26, and a microphone boom 28. Headband 22 includes a head element 30, having a head cushion 32
25 carried on the bottom side thereof. Ear cup supports 34, 36 are moveable on head element 30, to provide adjustment for ear cups 24, 26, respectively. Each ear cup 24, 26, is pivotally mounted on its respective ear cup support 34, 36, and includes an ear cup, or acoustic, seal

5 38, 39. A cord 40 extends from ear cup 26 and provides an electrical connection to LEDs 10, 11 through switches 50; to speakers (not shown) mounted in ear cups 24, 26; and to a microphone pickup element (not shown) carried in a microphone housing 44, located at one end of microphone boom 28. A volume control knob 46 may be located on ear cup 24 to control the volume of the sound produced by the acoustic transducers located in each ear cup 10 24, 26, as is known in the art.

Turning to FIGS. 2 and 3, headset 20 is shown on user 60. Headset 20 is shown illuminating the area of interest to the headset user/wearer 60, by directing light from LEDs 10, 11 generally in the same direction the headset wearer 60 is looking (as indicated by dashed lines in FIGS. 2 and 3). For clarity, FIG. 3 omits microphone boom 28.

15 Two toggle-type switches 50 are depicted in the embodiment shown in FIG. 2. In this embodiment, one switch 50 turns on and off first set of LEDs 10, and a second switch 50 turns on and off second set of LEDs 11. The embodiment shown in FIG. 2 shows two LEDs 10 and two LEDs 11. One LED 10 and one LED 11 can be used, or more than two of each can be used, or differing numbers of each. In a preferred embodiment, a first set of LEDs 10 20 generate white light, while a second set of LEDs 11 generate red light. In that embodiment the white LED is preferably a 3.6 volt, 20 milli-amp LED with a luminous intensity of 1,100 millicandelas (mcd) (a candela (1,000 mcd) is the amount of light that shines through a 1/16-inch square centimeter hole in one side of a ceramic box that has been heated to 1,772° C). The red LED is preferably a 1.7 volt, 20 milli-amp LED with a luminous intensity of 3,000 25 mcd. Any LED 10, 11 can be used that produces visible light in sufficient intensity to enhance the user's 60 vision. Further, if only a single set of one or more LEDs is provided

5 (e.g. only LEDs 10), then only one toggle or other switch needs to be included for turning on and off such LEDs.

While two toggle-type switches 50 are depicted in the embodiment shown in FIG. 2, one 3-way switch is depicted in the embodiment shown in FIG. 4. The 3-way switch shown in FIG. 4 has three positions: all LEDs off; only first set of LEDs 10 on; and only second set
10 of LEDs 11 on. In a preferred embodiment a 3-way switch is used that meets military specification 13AFWZ1, and is capable of operating at 6 amps at 125 volts. Any switch can be used that is capable of closing a circuit between LEDs 10, 11 and a power source when user 60 desires any of LEDs 10, 11 to illuminate.

As discussed above, a cord 40 can extend from ear cup 26 to provide electrical power
15 to LEDs 10, 11 through switch(es) 50. The power source may be, for example, a “hot” outlet that receives electrical power from an engine or battery, such as those in an airplane. Cord 40 may be separate from connection that provide electrical signals to ear cups 24, 26, or may be part of a multi-conductor cable which provides both signals to ear cups 24, 26 and power to LEDs 10, 11. However, the power source may be of any type sufficient to energize LEDs
20 10, 11. For instance, LEDs 10, 11 may draw power from a battery 30, as shown in FIG. 5. In a preferred embodiment, battery 30 is a Type 23A 12 volt battery, known as a 23-154. The battery 30 is preferably located inside, but may be located outside the headset 20. In other embodiments the cord 40 may provide back-up power in case of failure of battery 30, and/or cord 40 may recharge battery 30. FIG. 6 shows an embodiment with a battery 30
25 located inside the headset 20. In this embodiment battery access door 70 in ear cup 24 allows access to the battery 30.

5 A simple electric circuit useful for the present invention is shown in FIG. 7. The ground terminal 64 of LED 10 is connected with suitable electrical conduit to the negative or ground terminal of a battery 30 or other power source. The positive terminal 62 of LED 10 is connected with suitable electrical conduit to the positive terminal of a battery 30 or other power source through a switch 50. Activating the switch 50 to a first state closes the circuit, turning the LED 10 “on,” and activating the switch 50 to a second state opens the circuit, turning the LED 10 “off.” It is understood that several LEDs 10 can be connected to a power source (such as a battery 30) through one or more switches 50 serially, or in parallel.

 The electrical circuitry of a particular embodiment is shown in FIG. 8. The ground terminals of LEDs 10, 11 are connected to the electrical ground of a battery 30 and the electrical ground of cord 40 with #24 pin clamps 80 and black 24 gauge (AWG) wire 100. The electrically positive terminal of battery 30 and the electrically positive lead of cord 40 are connected to the power terminal of a 3-way switch 50, through a fuse (or circuit breaker) 90 and zener diode 110, using red 24 gauge (AWG) wire 120. The positive terminals of LEDs 10, 11 are connected to first and second terminals, respectively, of 3-way switch 50 with #24 pin clamps 80 and orange 24 gauge (AWG) wire 130. In this embodiment the cord 40 provides back-up and/or recharging power for battery 30. In other embodiments cord 40 or battery 30 may be deleted from the system. It is understood that multiple switches 50, such as toggle switches, may replace 3-way switch 50.

 Referring now to FIGS. 9-9A, retrofitting headgear (as an example, an aircraft headset) is shown, using parts in a kit. In one embodiment such a kit includes approximately 12 inches of 24 gauge (AWG) wire 100 (shown in FIG. 9A), two miniature two-way toggle switches 50, two white 1,100 mcd LEDs 10 and two red 3,000 mcd LEDs 11, two rubber

5 boots 140 (shown in FIG. 9B), a battery holder 150, a template 160, and instructions including a circuit diagram 170, illustrating a circuit such as those shown in FIGS. 7 or 8.

In this embodiment an LED illumination system is installed by removing ear cups, or acoustic, seals 38, 39 (and any other covering) from ear cups 24, 26, to gain access to the interior of ear cups 24, 26. Templates 160 are then affixed to the forward facing portions of
10 ear cups 24, 26. Per templates 160, two holes 162 (in one embodiment 3/16 inch diameter holes approximately 1/4 inch apart) are drilled in each cup 24, 26. The template 160 is removed after drilling. Two holes 164 are drilled in the side of one ear cup 24 for attachment of switches 50 (in one embodiment 3/16 inch diameter holes approximately 1/2 inch apart). LEDs 10, 11 are installed in holes 162, and switches 50 are installed in holes 164,
15 respectively using bracketry, fasteners, epoxy, molded rubber shapes, or the like (not shown). Battery holder 150 is installed in the interior of cup 24. In embodiments using an outside power source to power LEDs 10, 11, an additional hole 166 is drilled in the bottom of cup 26 for a power cord 40 (in one embodiment a 3/16 inch diameter hole). To protect cord 40, hole 166 may be fitted with a grommet (not shown) that may be supplied with the kit.

20 Continuing the installation, wire 100 is connected to the battery holder 150, switches 50 and LEDs 10, 11 per the wiring diagram 170. In order to run the wiring 100 from cup 24 to cup 26, the wiring 100 is preferably run along head element 30. To contain the wiring 100 as it runs along head element 30, rubber boots 140 are installed on ear cup supports 34, 36 and over wiring 100. In embodiments utilizing an external power cord 40, the cord 40 is run
25 through hole 166 and attached to wiring 100 and/or battery holder 150 per wiring diagram 170. Various elements of the kit may be attached to headset 20 using fasteners and/or glue, such as epoxy, if desired or necessary. Finally, a battery 30 is installed in battery holder 150,

5 ear cups, or acoustic, seals 38, 39 (and any other covering) are reassembled to ear cups 24,
26. The LEDs 10, 11 of retrofitted headset 20 should then be ready for use by actuating
switches 50.

FIG. 10 shows an embodiment of the general concept of an add-on device 200 for
adding LED illumination to existing headgear. Add-on device 200 comprises a housing 210
10 bearing one or more switches 50, which turn on and off LEDs 10, 11. A battery door 70 is
provided in the housing 210 to provide access to a battery 30 (not shown). The
electronics/electrical circuit inside housing 210 is similar to that shown in FIGS. 7 and/or 8
(not shown). Housing 210 defines an aperture 220 through which a fastener 230 (in one
embodiment, a #2 screw), passes. A portion of fastener 230 that passes through housing 210
15 attaches to clip 240. Clip 240 may be a spring-loaded clamp, adapted to clamp on to existing
headgear, such as an aircraft headset 20. Alternatively, clip 240 may be an integral part of
housing 210, or of a portion of housing 210, obviating the need for fastener 220.

Add-on device 200 is utilized by attaching clip 240 to headgear worn by a user such
that LEDs 10, 11 are positioned to direct light in the desired direction; manipulating fastener
20 230 to tighten clip 240 onto headgear, such as headset 20, so that add-on device 200 is not
prone to move relative to said headgear; and actuating switch(es) 50 to turn LEDs 10, 11 on
and off. In embodiments without fastener 230, the clip 240 may simply be released, allowing
the clip 240 to clamp onto said headgear using the preload of the spring in clip 240.

While the invention has been illustrated and described in detail in the drawings and
25 foregoing description, the same is to be considered as illustrative and not restrictive in
character, it being understood that only the preferred embodiment has been shown and
described and that all changes and modifications that come within the spirit of the invention

5 are desired to be protected. For example, but not by way of limitation, additional embodiments include providing a compact, lightweight LED flashlight with existing headgear, such as spectacles, hats, helmets, and headbands.